Research Product 86-31

A Self-Correcting Compass Course for Training Dead Reckoning

ARI Field Unit at Fort Benning, Georgia

Training Research Laboratory

October 1986



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Dead reckoning involves naviga	ating by distance	e (pace count) and direc-
tion (compass azimuth). The purpos	se of this paper	is to describe a self-
correcting compass course designed		- · · · · · · · · · · · · · · · · · · ·
computer program has been written t		
and distance for each leg of the co	ourse, facilitat:	ing course set up. The

compass course can be easily modified to work in any training area to assist

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and reinforce training on dead reckoning. Similar courses have been used by the Rangers and Special Forces to increase soldiers' confidence in their navigational abilities. Advantages of the new course include its self-correcting aspect and the fact that the soldier is forced into using an accurate pace count.

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Research Product 86-31

A Self-Correcting Compass Course for Training Dead Reckoning

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Training Land Navigation

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As part of the U.S. Army land navigation training, every soldier learns to use a compass and measure distance using a pace count. This form of navigation is called dead reckoning. Although dead reckoning is an important navigational technique, effective means for developing azimuth and distance determination skills are lacking.

In response to this problem, the Army Research Institute, in cooperation with the U.S. Army Infantry Center at Fort Benning, Georgia, developed a self-correcting compass course, which can be used in a parking lot or in a field and which is designed to test a soldier's ability to use a compass and pace count. An accompanying computer program that enables the instructor to specify training area dimensions and that provides randomly generated azimuths and distances for the course set-up was written.

EDGAR M. JOHNSON

Technical Director

EXECUTIVE SUMMARY

Requirement:

All soldiers need to know how to use a compass and to determine distance using a pace count. However, there is currently a lack of effective means to train these dead-reckoning skills. In response to this need, a compass course that can be set up quickly, provide detailed error information, allow varying number of soldiers to train simultaneously, and be used in a variety of training areas was developed.

Procedure:

A compass course was set up so that the outline of stakes formed two concentric rectangles. The use of concentric rectangles forced the navigator to use both azimuth and distance, the two components of dead reckoning. A computer program was written so instructors could specify course dimensions; the azimuth and distance for each leg of the course can be generated to facilitate course set-up.

Findings:

The self-correcting compass course offers opportunities for dead reckoning and land navigation training enhancement. The training advantages to this course are that it can be used in areas of limited size, that soldiers are in an easily controlled area, and that errors are self-correcting.

Utilization of Findings:

The self-correcting compass course is designed for use in both unit and institutional settings and can be used to improve dead reckoning skills. The computer program allows the trainer to specify course dimensions to accommodate virtually any training area. In addition to facilitating course set-up, the computer-generated azimuth and distance information allows for the detection and correction of soldiers' errors during dead reckoning training.

A SELF-CORRECTING COMPASS COURSE FOR TRAINING DEAD RECKONING

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A SELF-CORRECTING COMPASS COURSE FOR TRAINING DEAD RECKONING

INTRODUCTION

Move, shoot and communicate is every soldier's mission. However, teaching the soldier to navigate accurately and effectively can be a trainer's nightmare. This is especially true when personnel at city-based Reserve Officers' Training Corps (ROTC) and Reserve components are required to teach and practice navigational techniques where training areas and/or the terrain may be limited.

Dead reckoning is the ability to navigate by following an azimuth and using a pace count. It is an easily taught land navigation skill that is useful in dense terrain, such as jungles, as well as in low-visibility conditions. Ranger and Special Forces cadre use a compass course to increase soldiers' skills and confidence in dead reckoning. For example, if a soldier training to be a Ranger receives a NO GO on land navigation, he is required to receive additional dead reckoning training.

One course is embedded in an overgrown wooded area. The course consists of engineer stakes marked with numbers, placed in the ground in a rectangular pattern. The stakes are approximately 7.62 meters apart with the overall dimension of the course approximately 38.10 meters by 68.58 meters. Each soldier is given a series of azimuths and corresponding distances and is required to move from one point to another, recording the stake number as he goes. Upon finding the required number of stakes (3 to 10), he returns to the instructor for feedback on his performance.

This type of compass course provides an effective means for evaluating a soldier's ability to follow an azimuth. However, the use of only a single rectangular array of stakes does not provide for the evaluation of both dead reckoning skills, that is, following both an azimuth and pace count. Additionally, scoring is a problem. The soldier is given all azimuths and corresponding distances prior to navigating the course. Thus if the soldier makes an error on an initial leg, then subsequent legs also will be in error.

There are at least two ways in which this course can be improved. First, to evaluate pace count, a concentric rectangle of stakes is required. This second rectangle of stakes forces the navigator to discriminate distance between two stakes along the same azimuth. The second way to improve the course is to rectify the scoring problem. This can be done by making the course self correcting. In other words, instead of giving the soldier all azimuths and corresponding distances prior to navigating the course, he is given a starting stake, from there, a new azimuth and distance is provided at each successive stake.

SELF-CORRECTING COMPASS COURSE

On an open parade ground, 200 meters by 260 meters, stakes (numbered tent pegs) were laid flush to the ground so that the soldier could not sight on the stakes. The distance between stakes was 20 meters. An inner rectangle of

stakes was added. The inner rectangle required the soldier to use both azimuth and pace count to determine the correct stake number. For example, if the target stake was a stake in the inner rectangle, but the soldier's pace count was long, he would end up between the inner and outer rectangle. Therefore, he must attend more closely to his pace, or adjust his 100 meter pace count for that terrain. Thus, a soldier's error was detected if he strayed to the left or right, or was long or short of the intended goal. Figure 1 represents the course layout.

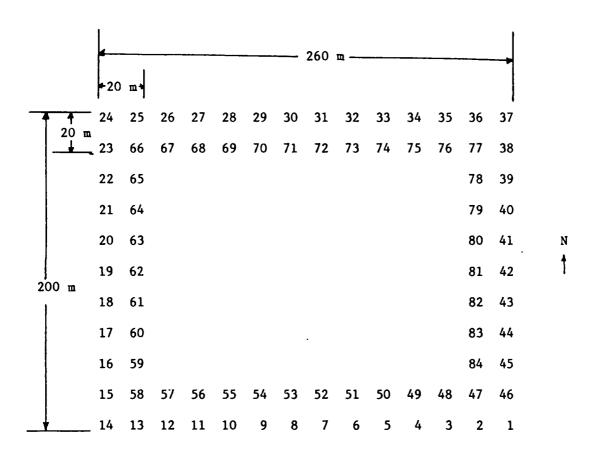


Figure 1. Self-Correcting Compass Course

To begin the field exercise, the soldier received a starting stake (1, 2, 3, . . . 84) and lane identifier (A, B, C, . . . J). From this point, he checked his lane identifier (e.g., 1A) to determine his required azimuth and distance. After traversing the distance, he marked the stake number on his score sheet.

He recorded his next azimuth and distance, which were posted on the stake, based on his original starting lane letter. The following would be located at Stake #1.

1	an	e	Α	В	С	D	•	•	•	•	. J
Stake	1	AZ	333	305	329	312					321
		DIST	224	316	233	297					256

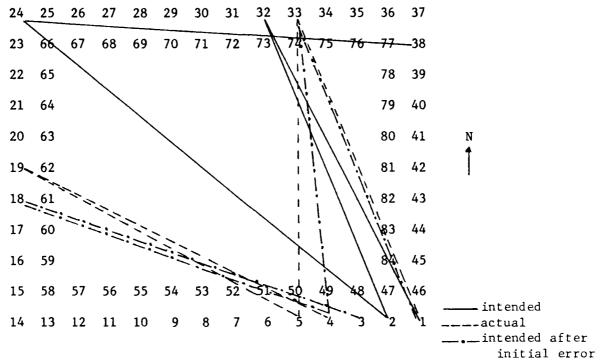
The course was designed to be self-correcting. For example, if the soldier went to an incorrect stake, he was given an azimuth and distance based on that stake. Upon returning to the scoring/instructor area, his errors (short/long pace or left/right drift) were identified. In the example below, a soldier was assigned to 1A and was required to find four stakes.

Route			Starting Stake Lane A	#1
	AZ DIST	333 224	Correct Stake	#32
	AZ DIST	158 215	Correct Stake	#2
	AZ DIST	309 312	Correct Stake	#24
	AZ DIST	94 261	Correct Stake	#38

However, if on the first leg and each successive leg, the soldier drifted to his right, then his route resulted in the following course:

Route			Starting Stake	#1
	AZ	333	Correct Stake	#32
	DIST	224	Went to #33	
	AZ	174	Correct Stake	#4
	DIST	201	Went to #5	
	AZ	294	Correct Stake	#18
	DIST	197	Went to #19	
	AZ	114	Correct Stake	#3
	DIST	224	Went to #4	

After outlining the intended course versus the actual course (see Figure 2), the instructor's feedback on this soldier's performance was that he continually drifted to the right and must compensate for this drift. The instructor also emphasized that this error would become much worse over extended distances.



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Figure 2. Intended and Actual Routes

COMPUTER PROGRAM

This course could be initiated easily and used in any training area. The following is a "flowchart" for the computer program:

- 1. Dimension Navigational Course matrix, Path Number matrix, Distance array, Azimuth array and "Its's Chosen" array.
- 2. Initialize variables

- 3. Ask to output to Console or Printer. Open device accordingly.
- 4. Get navigational course information.
- 5. Set up navigational course matrix and print it.
- 6. Get starting stake number and find coordinates (x1,y1).
- 7. Set error value to 0. Get proposed path stake number and find coordinates (x2,y2).
- 8. Find distance and azimuth.
- 9. Check stake number, distance and azimuth for errors. Set error value.
- 10. If error value is 1 then go to 7.

- ll. Set stake number in "its's chosen" array.
- 12. If more paths then go to 7.
- 13. Print distance and azimuth for paths per starting stake number.
- 14. Clear "it's chosen" array.
- 15. If more starting stake numbers then go to 6.
- 16. Print chosen stake number for paths per starting stake number.
- 17. END.

A computer program, written in Basic (see Appendix A), was used to generate the azimuth and distances for the compass course (see Appendixes B and C for azimuths/distances and correct stakes, respectively). Refer to Appendix D for course layout, equipment, instructions, and scoring procedures.

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APPENDIX A

BASIC SELF-CORRECTING COMPASS COURSE

```
001 Rem Land Navigation Program
002 Rem Self Correcting Compass Course
003
    Rem Written by William H. Greene
004
005
    Dim nc$ (20,20), pn%(20,400), ds%(20), az%(20), ic%(400)
    for y = 1 to 20: for x = 1 to 20: nc$(x,y)="": next x: next y:
      c$ = chr$(147): ch$ = chr$(19)
     print c$; "Do you want output to": print "(p)rinter": print:
007
      print "(c)onsole": d = 4
800
     input a$: if a$ = "c" then d = 3
009
     Rem
010 Rem Main Program Logic
011 open 4, d, 7: print #4, c$;: gosub 100: gosub 200: poke 53280, 0:
      poke 53281, 0
012
     print #4, ch$; c$;: for s = 1 to ns: z = s: gosub 300: x1 = x: y1 = y
013
    for p = 1 to np: er = 0
     pn\%(p,s) = int(rnd(1) * (ns) + 1): if pn\%(p,s) = s then 14
015
    z = pn\%(p,s): gosub 300: x2 = x: y2 = y: gosub 400: gosub 500:
      if er \Leftrightarrow 0 then er = 0: goto 14
     ic%(pn%(p,s)) = 1: next p: sl = 1: gosub 600: for a = 1 to ns:
      ic%(a) = 0: next a: next s
017
     print #4, ch$; c$;: s1 = 4: gosub 700: print #4, ch$;: close 4: end
018
    Rem
099
    Rem Navigational Course Setup
100
     input "enter number of stakes east-west"; e: if e > 20 then gosub 120:
      goto 100
101
     input "enter number of stakes north-south"; n: if n > 20 then gosub 120:
102
     input "enter number of paths"; np: if np > 20 then gosub 120: goto 102
     input "double rows-columns(1-n / 2-y)"; rc: if rc \langle 1 or rc \rangle 2 then 103
103
    input "enter distance between stakes"; ud
104
105 input "enter minimum path distance"; mp: if mp < 1 then goto 105
106 ns = (e * n) - ((e - rc * 2) * (n - rc * 2))
    ne = (e - 1) * ud: nn = (n - 1) * ud
107
    print #4, " your course is"; e; "stakes east-west and"
108
109
     print #4, n; "stakes north-south. You will have"
110 print #4, ns; "stakes with"; ud; "meters between each."
     print #4, " The size of your course is"; ne; "meters"
print #4, " east-west by"; nn; "meters north-south.": print #4, np;
111
112
     print #4, "Paths will be plotted from each"
113
     print #4, " stake. The minimum path distance is": print #4, mp; "meters."
114
     t\$ = "": for i = 1 to e: t\$ = t\$ + "": next i
116
117
     print #4: print #4, t$; " N": print #4, t$; "W + E": print #4, t$; " S":
      print# 4
119
120 print "must be less than 20": for i = 1 to 2000: next: return
198 Rem
199 Rem Setup stake# to nc$-location
```

```
200 print #4: sn = 1: for y = 1 to rc: for x = 1 to e: nc$(x,y) = str$(sn):
      sn = sn + 1: next x: next y
202 for y = (rc + 1) to (n - rc): for x = 1 to rc: nc$(x,y) = str$(sn):
      sn = sn + 1: next x
203 for x = (e + 1 - rc) to e: nc\$(x,y) = str\$(sn): sn = sn + 1: next x:
204
     for y = (n - rc + 1) to n: for x = 1 to e: nc\$(x,y) = str\$(sn):
      sn = sn + 1: next x: next y
205
     \ln = \text{len } (\text{nc}(e,n)): for y = 1 to n: for x = 1 to 3
206 lc = len (nc(x,y)): if lc (x,y) = " " + nc<math>(x,y):
      goto 206
207
     print #4, nc$(x,y);: next x: print #4: next y: return
298 Rem
299 Rem Find x,y coordinates of stake#
300 for y = 1 to n: for x = 1 to e: if z = val(nc\$(x,y)) then return
301
     next x: next y: er = 1: return
398
    Rem
399 Rem Find Distance and Azimuth
400 cx = x1 - x2: cy = y1 - y2: ds%(p) = int(sqr(cx**2 + cy**2) * ud + .5):
     if cx = 0 then er = 1: goto 410
401 az\%(p) = int((atn (cy / cx) * 180 / 3.14) + .5)
402 if cx < 0 then az%(p) = 90 + az%(p): goto 410
403 az\%(p) = 270 + az\%(p)
410 return
498 Rem
499 Rem Error Trapping Routine
500 if er <> 0 then return
501 if x1 = x2 or y1 = y2 then er = 1: return
502 if ds%(p) < mp then er = 1: return
503 if ic\%(pn\%(p,s)) \Leftrightarrow 0 then er = 1: return
504 return
598 Rem
599
    Rem Print Routine for Distance and Azimuth
600 if s = 1 or f1 = 1 then gosub 800: f1 = 0
601 ls$ = "": if s < 100 then ls$ = " ": if s < 10 then ls$ = "
602 11 = len (str(s)): s = ls+ mid(str(s), 1, 11) + " ds":
      print #4, s$;
     d\$ = "": for p = 1 to np: 1s\$ =" ": if ds\%(p) < 100 then 1s\$ = "
603
      if ds%(p) < 10 then ls$ = "
604
    d\$ = d\$ + ls\$ + str\$(ds\%(p)): next p: print #4, d\$: d\$ = "
605 for p = 1 to np: 1s = " ": if az%(p) < 100 then 1s$ ="
      if az%(p) < 10 then ls$ = "
606
    d$ = d$ + 1s$ + str$(az%(p)) :next p: print# 4, d$
607 print# 4, hl$: ifs / 19 = int (s / 19) then fl = 1
608 return
698 Rem
699
    Rem Print Routine for Chosen Stakes
    for s = 1 to ns: if s = 1 or fl = 1 then gosub 800: fl = 0 1s$ = "": if s < 100 then 1s$ = " : if s < 10 then 1s$ = "
700
711
712 11 = len (str$ (s)): s$ = 1s$ + mid$(str$(s), 1, 11) + " pt":
      print# 4, s$;: d$ = ""
```

```
713 for p = 1 to np: ls$ = " ": if pn%(p,s) < 100 then ls$ =" ":
    if pn%(p,s) < 10 then ls$ = " "

714 d$ = d$ + ls$ + str$(pn%(p,s)): next p: print #4, d$

715 print #4, hl$: if s / 27 = int(s / 27) then fl = 1

716 next s: return

798 Rem

799 Rem Page Header Routine

800 h$ = " ": for l = 1 to np: h$ = h$ + " " + chr$(64 + 1): nest l

801 ll = len(h$) + l: hl$ = "": for l = 1 to ll : hl$ = hl$ + "*": next l

802 for lf = 1 to sl : print #4: next lf: print #4, h$: print #4, hl$: return ready.
```

APPENDIX B

Azimuth & distances for 200 m by 260 m area

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APPENDIX C

Answer stakes for 200 m by 260 m area

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APPENDIX D

COMPASS COURSE REQUIREMENTS

Materials needed:

- 1. Stakes (e.g., tent pegs, surveyor's stake, coffee can tops)
- 2. Meter measuring tape
- 3. Compass
- 4. Azimuth/distance marking at each stake
- 5. Score sheet for each student
- 6. Compass for each student
- 7. Pencil for each student
- 8. Mapped answer sheet for each student
- 9. Master answer sheet

Information at each stake:

- 1. Stake number
- 2. Azimuth and distance for each lane identifier

Instructions to soldiers:

- Self-correcting compass course
- 2. Use azimuth and pace count
- 3. Given starting stake and lane identifier (e.g., 1A, 10J)
- 4. At each stake, given azimuth and distance for next leg
- 5. Write stake number on score sheet
- 6. After finding X number of stakes, return to scoring area

Scoring:

- 1. Provide course lay out for each student
- 2. Indicate "correct" route (this can be marked prior to training)
- 3. Indicate "route taken"
- 4. Identify errors (i.e., stray to left, right, pace too long, too short)
- 5. Recommend ways of correcting errors (e.g., recount 100 meter pace)